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MARTIN
MARIETTA
CORPORATION
DENVER DIVISION

VOYAGER
CAPSULE

PRELIMINARY DESIGN (Phase B)

Contract Number 952001 FINAL REPORT

VOLUME IV ENTRY SCIENCE PACKAGE
Section V Interfaces

AUGUST 31, 1967

A. J. Kullas
Voyager Program Director

FOREWORD

This document is submitted in accordance with paragraph (a) (9) of Article 1, Statement of Work, to California Institute of Technology Contract No. 952001, which is a subcontract under NASA Contract NAS7-100. This document (⟶) is part of the Final Technical Report which consists of the following:

Vol I	Summary
	CAPSULE BUS SYSTEM
Vol II, Section I	Capsule Bus
Vol II, Section II	Preliminary Design for OSE
Vol II, Section III	Implementation Plan
Vol II, Section IV	Test Program
	SURFACE LABORATORY SYSTEM
Vol III, Section I	Surface Laboratory
Vol III, Section II	Preliminary Design for OSE
Vol III, Section III	Implementation Plan
Vol III, Section IV	Test Program
	ENTRY SCIENCE PACKAGE
Vol IV, Section I	Entry Science Package
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Vol IV, Section IV	Test Program
⟶ Vol IV, Section V	Entry Science Package Interfaces
Vol V	Interface Descriptions
*Vol VI	RTG Report
*Vol VII	A Flight Capsule with RTG for 1973 Mission

*Limited distribution of Vol VI and VII has been made as directed by JPL.

MARTIN MARIETTA CORPORATION

DENVER DIVISION

PREFACE

This volume of the Martin Marietta Corporation's Voyager Capsule Systems Final Report provides the results of the Entry Science Package preliminary design studies. In the performance of this Phase B study effort, Martin Marietta was assisted by RCA Astro-Electronics Division in the communications subsystem area, and by the following group of consultants in the Entry Science area.

	Fields of Specialty
Institute for Aerospace Science University of Toronto (J. H. deLeeuw, J. B. French	Free Molecular Flows and Molecular Beams
Cornell Aeronautical Laboratory, Inc. (Vidal, P. Marrone)	Hypersonic and Supersonic Flow
High Altitude Engineering Laboratory Dept. of Aerospace Engineering University of Michigan (L. Jones, E. Schaefer)	High Altitude Atmospheric Structure and Measurements

This volume consists of five sections: Section I, Entry Science Package; Section II, Preliminary Design for OSE; Section III, Implementation Plan; Section IV, Test Program; and Section V, Interfaces.

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1. GENERAL APPROACH

Martin Marietta recognizes the importance of the systems integration of the Capsule Bus, the Entry Science Package and the Surface Laboratory. The task of systems integration begins with comprehensive definition of systems requirements at the interfaces. Only then can compatibility be achieved within the integrated system, and at the interfaces it presents to the other systems. Interfaces to be considered include hardware, software, and services as they are affected by physical, functional, environmental, test, and operational requirements plus the managerial relationships to be established.

1.1 Objectives

The objectives of the Voyager interface management program are to achieve compatible system interfaces by detailed interface definition and formal change management so that the task of systems integration can proceed. This document summarizes the contractor's recommendations for the interface management program with and within the Voyager Capsule systems as a result of the Phase B study. Section 2 identifies and provides preliminary definition of Voyager capsule systems interfaces and section 3 proposes methods for accomplishment of contractor-customer coordination, negotiation and control of interfaces.

2. SPECIFIC INTERFACES

The interfaces described in the following paragraphs are the recommendation of the contractor for identification, documentation, and configuration control. Interfaces exist between the Capsule Bus and the Entry Science Package, and between the combination of these (as a Flight Capsule) and the Spacecraft. (Because the Capsule Bus supports the Entry Science Package in interfacing the Flight Capsule with the spacecraft during interplanetary cruise, these interfaces are referenced to the Capsule

Bus.) Furthermore, the Capsule Bus and the Entry Science Package each have interfaces with ground based systems.

2.1 Flight Capsule Interfaces

2.1.1 Flight Capsule to Spacecraft

The physical and functional interfaces between the Flight Capsule and Spacecraft will be accommodated by the Sterilization Canister/Adapter portion of the Capsule Bus, which performs the following functions:

a) The encapsulating cover maintains the sterility of the Flight Capsule

b) Provides the structural support and attachment points for adapting the Flight Capsule to the Spacecraft

c) Provides for housing and installation of equipment required to support the Flight Capsule systems before separation

d) Provides electrical connections between the Flight Capsule systems and the Spacecraft

e) Provides energy storage devices, including safing and arming features, required for removing the encapsulating canister cover from the Flight Capsule

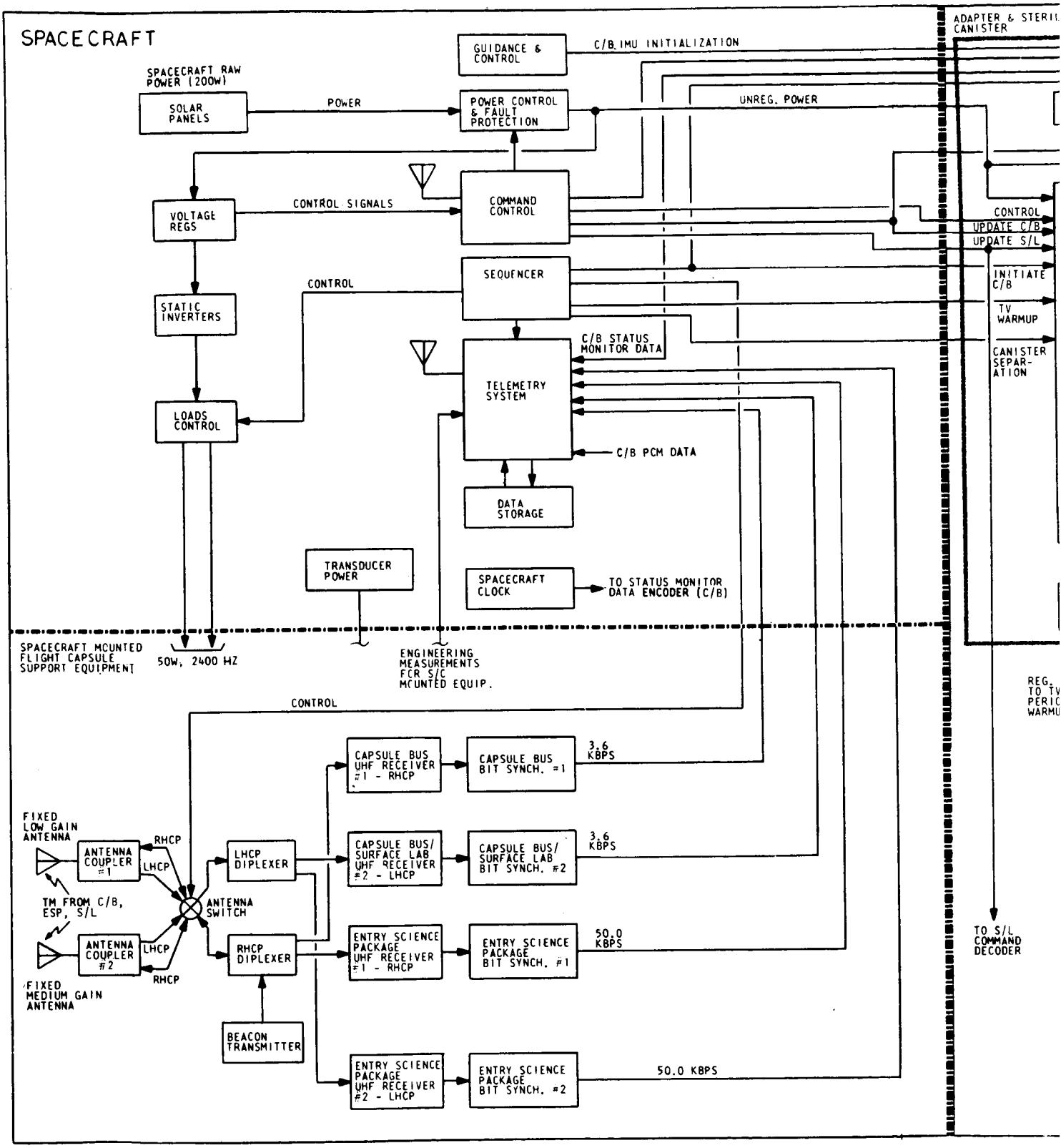
f) Provides energy storage devices, including safing and arming features, required for removing the thermal barrier

g) Provides energy storage devices, including safing and arming features, for separating the Flight Capsule from the Spacecraft

h) Provides structural and electrical separation planes for Flight Capsule separation.

In fulfilling the Flight Capsule interface requirements with the Spacecraft, the Capsule Bus will accommodate the requirements of the Entry Science Package.

A block diagram of adapter-mounted equipment is shown in Fig. 1.


SPACECRAFT
ADAPTER & STERIL
CANISTER
GUIDANCE & CONTROL
C/B IMU INITIALIZATION
SPACECRAFT RAW POWER (200W)
SOLAR PANELS
POWER
POWER CONTROL & FAULT PROTECTION
UNREG. POWER
VOLTAGE REGS
CONTROL SIGNALS
COMMAND CONTROL
CONTROL
UPDATE C/B
UPDATE S/L
SEQUENCER
INITIATE C/B
TV WARMUP
STATIC INVERTERS
CONTROL
C/B STATUS MONITOR DATA
CANISTER SEPAR-ATION
TELEMETRY SYSTEM
LOADS CONTROL
C/B PCM DATA
DATA STORAGE
TRANSDUCER POWER
SPACECRAFT CLOCK
TO STATUS MONITOR DATA ENCODER (C/B)
SPACECRAFT MOUNTED FLIGHT CAPSULE SUPPORT EQUIPMENT
50W, 2400 HZ
ENGINEERING MEASUREMENTS FOR S/C MOUNTED EQUIP.
REG. TO TV PERIO WARMU
CONTROL
CAPSULE BUS UHF RECEIVER #1 - RHCP
CAPSULE BUS BIT SYNCH. #1
3.6 KBPS
FIXED LOW GAIN ANTENNA
ANTENNA COUPLER #1
RHCP
LHCP
LHCP DIPLEXER
CAPSULE BUS/ SURFACE LAB UHF RECEIVER #2 - LHCP
CAPSULE BUS/ SURFACE LAB BIT SYNCH. #2
3.6 KBPS
TM FROM C/B, ESP, S/L
ANTENNA SWITCH
ANTENNA COUPLER #2
LHCP
RHCP
RHCP DIPLEXER
ENTRY SCIENCE PACKAGE UHF RECEIVER #1 - RHCP
ENTRY SCIENCE PACKAGE BIT SYNCH. #1
50.0 KBPS
TO S/L COMMAND DECODER
FIXED MEDIUM GAIN ANTENNA
BEACON TRANSMITTER
ENTRY SCIENCE PACKAGE UHF RECEIVER #2 - LHCP
ENTRY SCIENCE PACKAGE BIT SYNCH. #2
50.0 KBPS

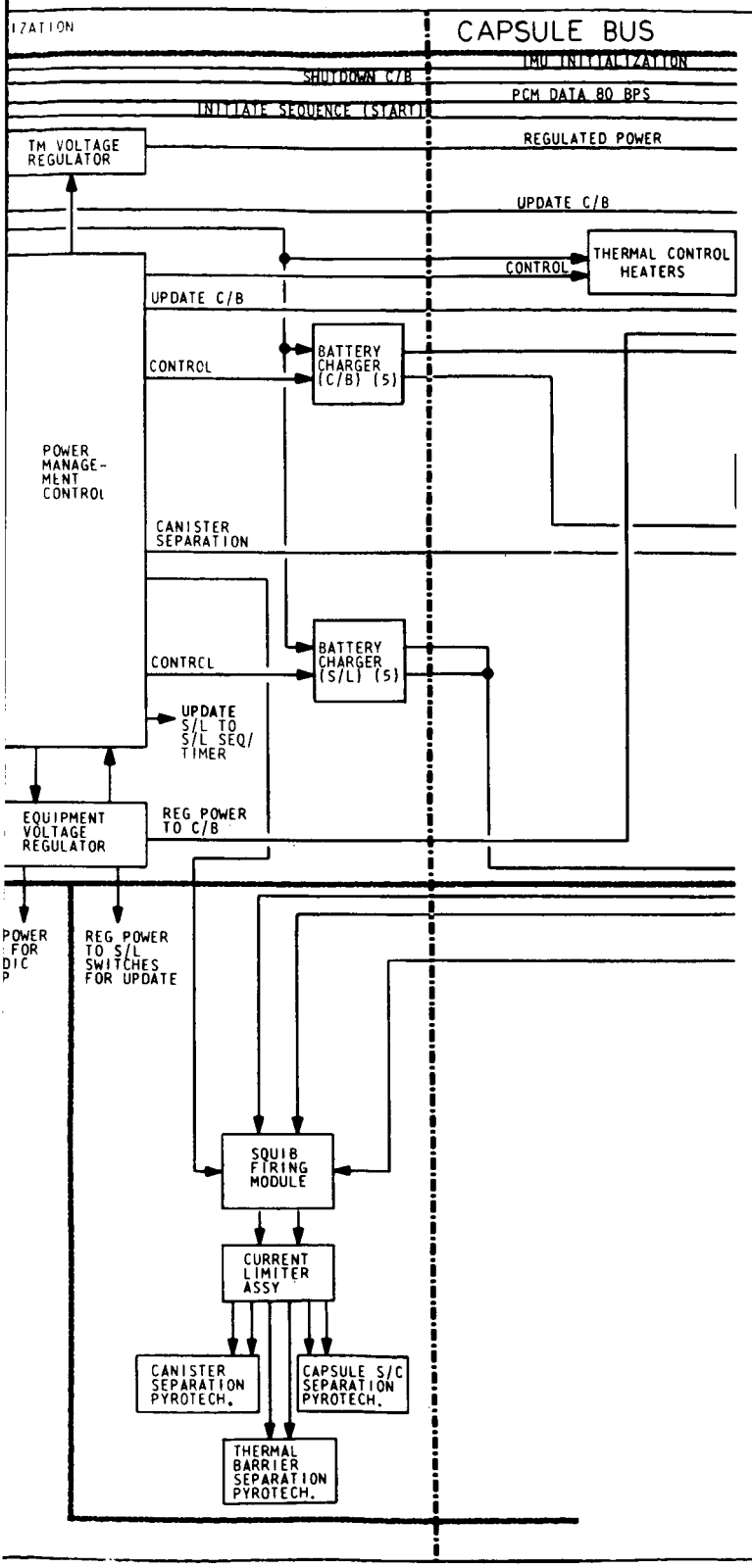


FIGURE 1 - BLOCK DIAGRAM OF FLIGHT CAPSULE/SPACECRAFT INTERFACES

2.2 Entry Science Package Interfaces

2.2.1 Entry Science Package to Capsule Bus

2.2.1.1 Structures and Mechanisms

One equipment module of the Entry Science Package will be located in the nose of the aeroshell behind a quartz window provided for TV. The other modules will be located in an equipment bay in the +X, -Y quadrant. Other requirements include:

a) Proper field of view for instruments

b) Locating the communication subsystem antenna on the roll axis to maintain proper aspect angles to view the orbiting Spacecraft during entry

c) Mounting the antenna so that discontinuities in the effective RF ground plane are not exaggerated

d) Maintenance of structural references for the entry science instruments so that significant uncertainties are not contributed to entry measurement data

e) Use of existing structure to shield interconnecting cables from radiated RF energy, wherever possible

f) Providing structural mounting points for modules that are corrosion resistant, propellant compatible, and electrically conductive

g) Passive thermal control of science instruments

2.2.1.2 Command and Sequencing

Checkout of the Entry Science Package will be accomplished by the sequencer timer and command decoder in the Capsule Bus prior to Flight Capsule separation from the Spacecraft. The Entry Science Package will receive the following discretes from the sequencer timer of the Capsule Bus after Flight Capsule separation from the Spacecraft:

a) Five primary discretes in the interval between T-1800 sec and T+502 sec where T = 0 is the beginning of entry

(800,000 ft). These discretes will initiate primary sequences in the ESP sequencer timer. In addition, power will be interrupted at T+622

b) Discretes to provide backup for operating and data transmission mode changes initiated by the ESP sequencer timer.

These discrete signals will have the following characteristics:

Voltage	28 vdc nominal
Input impedance	10 K ohms minimum
Time	-momentary, 100 ms minimum

2.2.1.3 Science Data (Telemetry)

A two-wire (twisted and shielded) interface will be provided between each status monitoring measurement in the Entry Science Package and the Capsule Bus. Signals having the following characteristics will interface with the status monitor data encoder in the Capsule Bus:

Analog signals

Voltage	0-50 mv dc
Source impedance	500 ohms max

Bilevel signals

Binary one	5 vdc 1
	5 k source impedance
Binary zero	0.4 vdc $\pm$ 0.4
	1 ma current

Signals not having these characteristics will be conditioned in the Capsule Bus.

Analog signals will be provided from atmospheric-science data sensors in the Entry Science Package to the data encoders of the Capsule Bus. This interface will allow real-time and back-up transmission of entry data to the Spacecraft.

2.2.1.4 Power

The Entry Science Package will receive power from the Load Control Assembly in the Capsule Bus beginning 30 minutes prior to

entry and ending two minutes after landing, when the Entry Science Package and Capsule Bus subsystems are shut down. Redundant two-wire circuits will cross the interface to the load control assembly of the Entry Science Package. Voltage will be 24 v to 33 v. Power will be provided from the Capsule Bus transducer power supply for Entry Science Package status monitor measurements and from the equipment voltage regulator to periodically activate Entry Science Package vidicon cathodes to prevent cathode poisoning.

2.2.1.5 Cabling

Interfacing cables will be categorized and separately routed to minimize the possibility of circuit interactions. Separation distance between categories will be maintained at a minimum of four inches, except that it will be permissible to pass cables of different categories through connectors. Three categories of interfacing circuits have been identified:

a) Category A is the most susceptible to extraneous voltages and includes circuits with voltage levels less than 1 volt

b) Category B is of medium susceptibility and includes circuits with voltage levels between 1 volt and 10 volts or between 1 volt and 20 volts depending on the signal characteristics

c) Category C is of low susceptibility, but is not apt to induce voltage in neighboring circuits.

In addition to cable separation, protection against electromagnetic interference will be achieved by using twisted, shielded pairs; and in low-level circuits, double shielding may be required. Shielding will not be carried through interface connectors but will be grounded to Flight Capsule and Spacecraft structure on the respective sides of the interface. The grounding point may be at, or removed from, the interface as determined by analysis. Single-shielded circuits normally will be grounded at the receiving end with lengths of exposed wire and lengths of shield grounding straps

held to minimum lengths. Double-shielded circuits will have the inner shield treated like single shields, and the outer shield will be grounded at intermediate points along the length of the cable as required.

Flight Capsule circuit-return leads will be grounded at a single point in the Capsule Bus, and Spacecraft circuit return leads will be grounded at a single point in the Spacecraft.

Table 1 amplifies the preceding requirements.

2.2.1.6 Pyrotechnics

Pyrotechnics in the Entry Science Package required for deployment of the total temperature probe, and for calibration of the gas chromatograph, will be operated by power from the pyrotechnic power supply of the Capsule Bus. Safe/Arm assemblies, squib firing circuits, and current limiter assemblies will be provided in the Entry Science Package.

2.2.2 Entry Science Package to Spacecraft-Mounted Support Equipment

The Entry Science Package will have RF communications interfaces with the Spacecraft-mounted support equipment for data transmission.

2.2.2.1 RF Communications

The Entry Science Package will contain two transmitters operating at different frequencies in the 385 to 405 MHz Band. Each transmitter will be on line for the transmission of data during entry. A fixed medium gain and a fixed low gain receiving antenna mounted on the Spacecraft will be supplied as Spacecraft-mounted support equipment. An antenna switch will provide optimum utilization for each mission. Through control of Spacecraft orientation and attitude, this antenna will maintain proper aspect angles with respect to a fixed antenna provided as part of the Entry Science Package and mounted on the Capsule Bus structure. The orientation and attitude of the Entry Science Package antenna

Table 1 Cable Categorization, Shielding and Grounding

Circuit Function	Voltage/Current (Output or Sensitivity)	Total Circuit Loop Impedance (ohms)	Cable Category	Recommended Min Cable or Transmission Line	Recommended Minimum Shield Grounding
dc to 100 kHz or pulse and rise times greater than 5 microsec	< 10 mv	All	A	TDS	SP/MP
	10 mv - 1 v	< 200	A	T	NA
		≥ 200	A	TS	SP
	1 v - 20 v	< 200	B	T	NA
		≥ 200	B	TS	SP
	> 20 v	All	C	TS	SP
Pulse rise and/or fall times less than, or equal to, 5 microsec	<10 mv	All	A	TDS	SP/MP
	10 mv - 1 v	All	A	TS	SP
	1 v - 10 v	< 1000	B	TS	SP
		≥ 1000	B	TS	MP
	> 10 v	All	C	TS	MP
dc power	< 1 amp		B	T	NA
	≥ 1 amp		C	T	NA
EED	All	All	D	TS	MP
100 kHz or greater	All	All	E	Coax*	MP
Ground checkout	1 v - 20 v	5,000 max	F	TS	SP

* Coaxial cable impedances shall match circuit impedances.

Legend:

MP - Multipoint Ground
SP - Single-point Ground
T - Twisted
SP/MP - Combination shield ground (inner SP, outer MP)
TS - Twisted, single shield
TDS - Twisted, double shield

will be under the control of the Capsule Bus guidance and control subsystem. In addition to frequency separation, the two channels will be of opposite circular polarization. Radiated power from each transmitter will be 30 watts.

The two transmitter frequency channels will interface with two receiving channels that are part of the Spacecraft-mounted support equipment.

2.2.2.2 Data Rate

Two channels will be separately provided to the Spacecraft at a data rate of 50 kbps on a frequency of 380 to 420 MHz. The Spacecraft will provide temporary storage for these data streams and will relay the streams separately to earth after completion of transmission from the Entry Science Package.

2.2.3 Entry Science Package to Mission Operations System

The Mission Operations System (MOS) consists of the hardware, software and personnel required to direct the mission from injection to the end of Mars orbital and landed operations. The hardware consists of Mission Independent Equipment (MIE) and Mission Dependent Equipment (MDE). The MIE consists of the Deep Space Instrumentation Facility (DSIF), the Space Flight Operations Facility (SFOF), and the Ground Communications System. Software consists of planning and implementation documentation and computer programs or routines. Personnel are those provided by the contractor to plan the mission and to man the Capsule Bus flight operations team, which forms part of the overall MOS project organization.

2.2.3.1 MIE/MDE Interfaces

An Entry Science Package TV data processor and display will require space at the SFOF. This piece of MDE will physically interface with the data processing system, will require power (115 vac, 60 cps) and an air-conditioned environment.

2.2.3.2 Software

2.2.3.2.1 Documentation

The contractor will supply chapters relating to the Entry Science Package for the following planning information as part of the flight capsule documentation:

Support Instrumentation Document

MOS Requirements Document

Space Flight Operations

Space Flight Operations Test Plan

Space Flight Operations Memorandum

In addition, the contractor will prepare the following planning inputs relative to the Entry Science Package as part of the flight capsule documentation:

MOS Policy and Guidelines

MOS Plan

MDE Development Plan

MDE Performance Requirements

MDE Design Requirements

MDE Acceptance Requirements

Personnel and Documentation Development Plan

Personnel and Documentation Performance Requirements

Personnel and Documentation Design Requirements

Computer Program Development Plan

Computer Program Performance Requirements

Computer Program Design Requirements

Computer Program Acceptance Requirements

Detailed Operating Procedures

DSN Failure Problem Report

2.2.3.2.2 Computer Programs

The contractor will functionally specify Entry Science Package-oriented computer programs and routines for data processing, Entry Science Package simulation, and generating commands.

2.2.3.3 Personnel

Contractor personnel will be assigned to the flight operations team at SFOF. This will require that desk, and work space and telephone service be provided by SFOF.

2.2.4 Entry Science Package to Experiments

The purpose of the entry science package experiments is to (a) obtain static and stagnation pressures and temperatures, density and composition of the Martian atmosphere as functions of altitude during descent to the Martian surface; (b) obtain entry flight-path velocity and acceleration as functions of altitude, and (c) obtain TV pictures of the Martian surface during terminal descent. To obtain these data, various sensors are provided by the Entry Science Package subsystem.

2.2.5 Entry Science Package to Launch Operations System

Interfaces between the Entry Science Package and the Launch Operations System are accommodated through the Capsule Bus. The requirements of the Capsule Bus are described.

2.2.5.1 Capsule Bus to Launch Operations System

Interfaces between the Capsule Bus and the Launch Operations System (LOS) will exist at the System Test Complex (STC) Control Center, the Saturn Launch Control Center, the Mobile Launcher Base, and the umbilical tower. These Capsule Bus interfaces include the requirements of the Entry Science Package. The OSE interfaces described are relative to a single Flight Capsule. All functions must be provided for two Flight Capsules integrated into two Planetary Vehicles for each launch. See Figure 2.

2.2.5.1.1 STC Control Center Interfaces

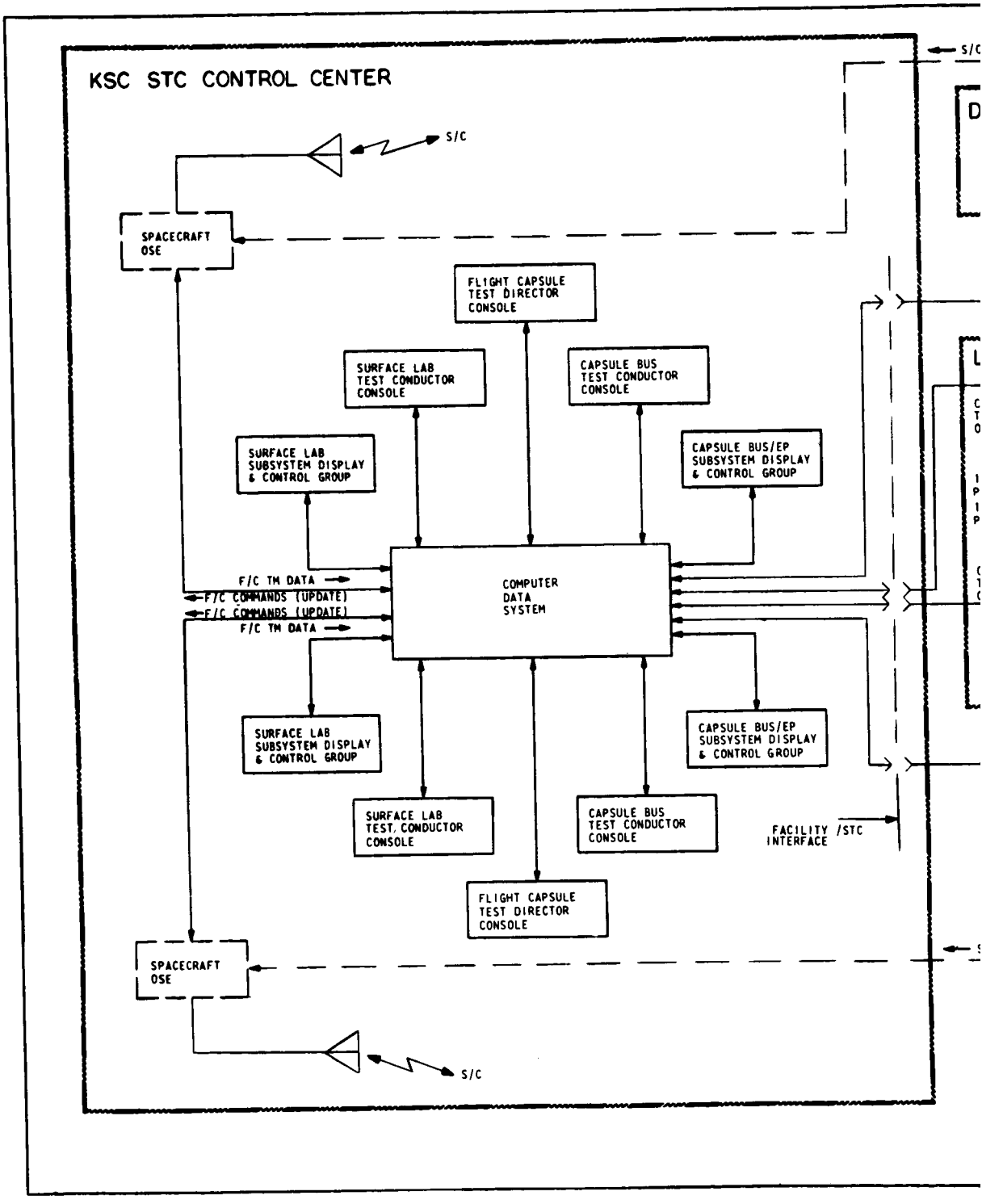
It is assumed that all prelaunch functions of the Flight Capsule, including the Capsule Bus, the Entry Science package, and the Surface Laboratory, are under the direction of a Flight Capsule test director. With this assumption, the following equipment will be required:

a) Flight Capsule test director console

b) Capsule Bus test conductor console

c) Capsule Bus subsystem/Entry Science Package display and control group

d) Computer data system.


KSC STC CONTROL CENTER
S/C
SPACECRAFT OSE
FLIGHT CAPSULE TEST DIRECTOR CONSOLE
SURFACE LAB TEST CONDUCTOR CONSOLE
CAPSULE BUS TEST CONDUCTOR CONSOLE
SURFACE LAB SUBSYSTEM DISPLAY & CONTROL GROUP
CAPSULE BUS/EP SUBSYSTEM DISPLAY & CONTROL GROUP
F/C TM DATA
F/C COMMANDS (UPDATE)
F/C COMMANDS (UPDATE)
F/C TM DATA
COMPUTER DATA SYSTEM
SURFACE LAB SUBSYSTEM DISPLAY & CONTROL GROUP
CAPSULE BUS/EP SUBSYSTEM DISPLAY & CONTROL GROUP
SURFACE LAB TEST, CONDUCTOR CONSOLE
CAPSULE BUS TEST CONDUCTOR CONSOLE
FACILITY /STC INTERFACE
FLIGHT CAPSULE TEST DIRECTOR CONSOLE
SPACECRAFT OSE
S/C

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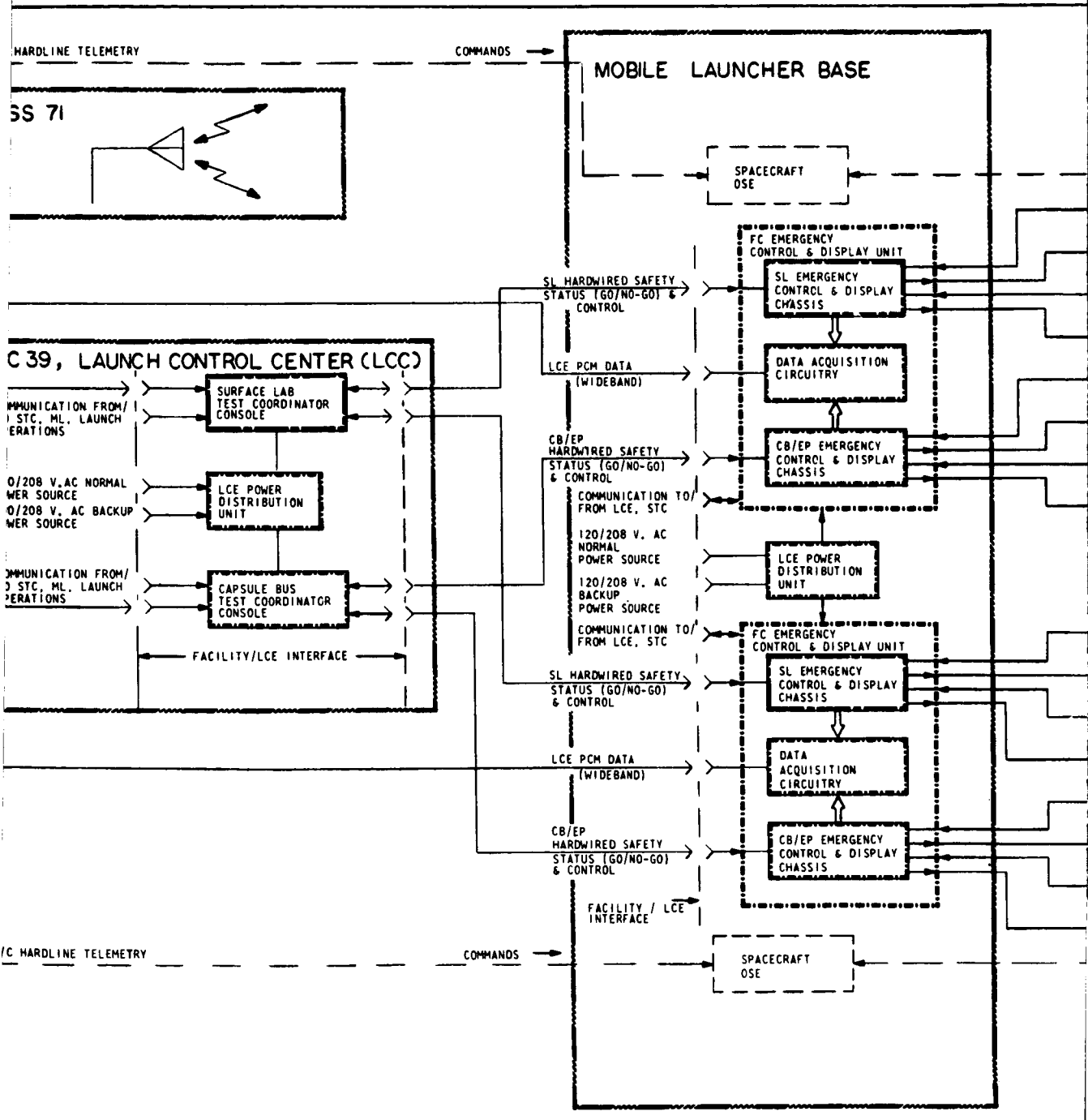
HARDLINE TELEMETRY
COMMANDS
MOBILE LAUNCHER BASE
SS 71
SPACECRAFT OSE
FC EMERGENCY CONTROL & DISPLAY UNIT
SL HARDWIRED SAFETY STATUS (GO/NO-GO) & CONTROL
SL EMERGENCY CONTROL & DISPLAY CHASSIS
LCE PCM DATA (WIDEBAND)
DATA ACQUISITION CIRCUITRY
CB/EP HARDWIRED SAFETY STATUS (GO/NO-GO) & CONTROL
CB/EP EMERGENCY CONTROL & DISPLAY CHASSIS
COMMUNICATION TO/ FROM LCE, STC
120/208 V. AC NORMAL POWER SOURCE
120/208 V. AC BACKUP POWER SOURCE
LCE POWER DISTRIBUTION UNIT
C 39, LAUNCH CONTROL CENTER (LCC)
SURFACE LAB TEST COORDINATOR CONSOLE
LCE POWER DISTRIBUTION UNIT
CAPSULE BUS TEST COORDINATOR CONSOLE
FACILITY/LCE INTERFACE
FACILITY / LCE INTERFACE
/C HARDLINE TELEMETRY
COMMANDS
SPACECRAFT OSE

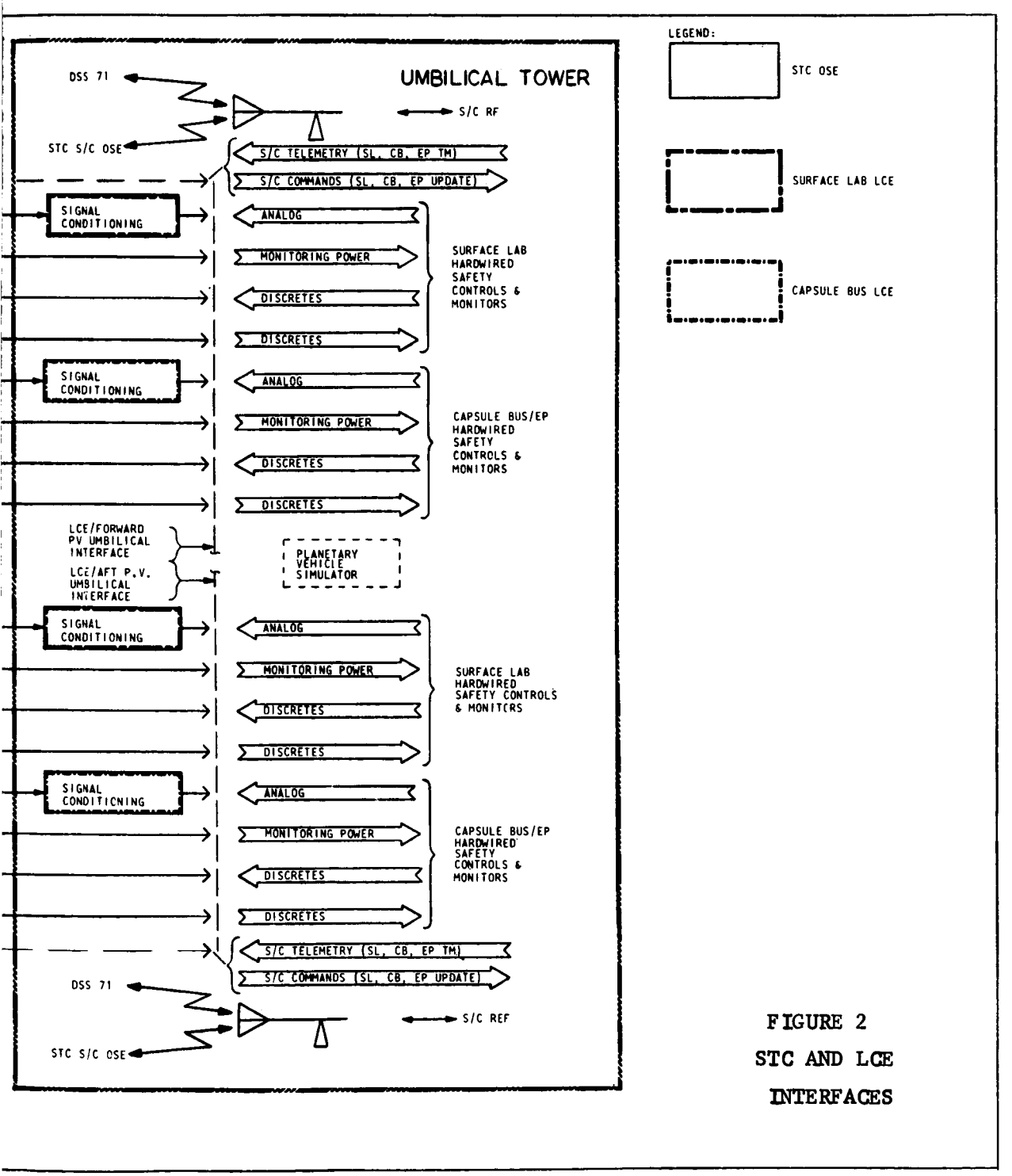

FIGURE 2
STC AND LCE
INTERFACES

Interfaces between these and the launch operations system will exist in the areas discussed in the following paragraphs.

2.2.5.1.1.1 Space

Space and provisions for installation, operation and maintenance of equipment will be required. Visibility and communications between consoles must be provided.

2.2.5.1.1.2 Power

Facility power (120/208 volt 60 cps) will be required.

2.2.5.1.1.3 Environmental

Equipment will be designed to operate in the controlled environment of the STC Control Center without special environmental demands on the facility.

2.2.5.1.1.4 Data Channels

Data channels among the STC Control Center, the Launch Control Center, and the Mobile Launcher Base will be provided by the LOS. A wide-band data transmission system (Western Electric A2A) is assumed. Flight Capsule status data and digital commands will be transmitted over these channels.

2.2.5.1.1.5 Spacecraft Telemetry Interfaces

It is assumed that Spacecraft OSE in the STC Control Center will provide RF links to receive Spacecraft telemetry data and transmit Spacecraft commands to/from the umbilical tower. These signals will interface with the Capsule Bus computer data system.

2.2.5.1.1.6 Communications Interfaces

Means for communications with other elements of the Launch Operations System (LOS) will be required at the Capsule Bus test conductor console.

2.2.5.1.2 Launch Control Center Interfaces

A Capsule Bus Test Coordinator Console will be required in the Launch Control Center LC 39. This console will provide data readout ability from the wide-band data transmission system and will provide emergency control of Flight Capsule OSE in the

Mobile Launcher Base. The control-circuit lines will be provided by the Launch Operations System, hardwired to the Mobile Launcher Base. Facility power (120/208V 60 cps) will be distributed to the Capsule Bus test coordinator console by a power distribution unit provided by the Capsule Bus contractor. Space and environmental interfaces will be comparable to those in the STC Launch Control Center.

2.2.5.1.3 Mobile Launcher Base Interfaces

Equipment required for support of the Capsule Bus and Entry Science Package in the Mobile Launcher Base will include the following:

a) Data Acquisition circuitry (shared with Surface Laboratory)

b) Capsule Bus/Entry Science Package emergency display and control chassis.

The above items will be installed in the Flight Capsule emergency display and control unit.

3. PROGRAM IMPLEMENTATION

The primary interfaces identified herein shall be defined, documented and controlled in accordance with the requirements of the interface program discussed in Volume V of this report. Further development in identification and definition of these interfaces will be accomplished as part of an overall interface program.